

**COMPARING THE VISUAL AND AUDITORY  
PRESENTATION OF INFORMATION**

**Willard F. Day  
Barbara R. Beach**

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UNIVERSITY OF VIRGINIA, CHARLOTTESVILLE

A SURVEY OF THE RESEARCH LITERATURE COMPARING THE  
VISUAL AND AUDITORY PRESENTATION OF INFORMATION

WILLARD F. DAY; BARBARA R. BEACH NOV'50 14PP

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## FOREWORD

This report is one of a series submitted by the University of Virginia to the USAF Air Materiel Command reporting research accomplished on visual message presentation under Contract No. W33-038 ac-21269. A survey of the literature comparing the visual and auditory senses as related to communication was one of the primary objectives of the contract as originally approved in May, 1948. This project was carried on under the supervision of Dr. R. H. Henneman of the Department of Psychology, University of Virginia. This project was sponsored jointly by the Communication and Navigation Laboratory and the Aero Medical Laboratory of the AMC Engineering Division. Technical supervision was provided by the Aero Medical Laboratory under Expenditure Order No. 594-37, with Mr. Julien M. Christensen as Project Engineer.

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## ABSTRACT

Recent studies have recently raised the question of the feasibility of developing a system of visual message presentation to supplement or replace the auditory system now used in aviation communication. Prerequisite to research on the development of a visual message presentation system would seem to be an experimental comparison of the visual and auditory senses as channels of communication. Antecedent to a series of laboratory studies comparing the relative intelligibility of messages presented aurally and visually a survey of the existing research literature in this field was taken. An answer to two questions was sought from previous investigations: (1) Is material better understood when presented visually or aurally? (2) Under what conditions and to what extent has one sense modality been found to be superior to the other?

About one half of the reported studies yield evidence for the superiority of visual presentation; the other half of the investigations support auditory superiority. It is obvious that the findings have been determined by the specific conditions of each experiment. Relevant factors appear to be the following: familiarity, degree of meaning, and difficulty of material; method of measuring comprehension (i.e., by ease of learning, or amount retained); and various characteristics of the observers (e.g., age, intelligence, social background, reading ability). A principal advantage of visual presentation springs from the possible referability which it affords. Combined visual and auditory presentation is more efficient than is either sense alone. In order to determine more specifically the relative superiority of the two senses for communication purposes, five specific areas of investigation are suggested in the present report.

### PUBLICATION APPROVAL

Manuscript copy of this report has been reviewed and found satisfactory for publication.

For the Commanding General:

*Walter A. Carlson*  
WALTER A. CARLSON

Colonel, USAF (C)

Chief, Aero Medical Laboratory  
Engineering Division

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## INTRODUCTION

### The Air Force Communication Problem

Wherever machines are used by men, the application of these mechanical devices is maximally efficient only to the extent that the mechanical perfection of the system is paralleled by a corresponding efficiency in the required associated human operations. The human functions involved in the use of machines are fundamentally operations of control and communication. Accordingly, the extraordinary technical progress that has been made in the post-war development of aircraft design has resulted in a more specific interest on the part of the Air Force in the engineering and psychological aspects of communications research.

Recent engineering developments in the design of communication transmission systems have indicated that in some ways a visual system of message presentation may be more suited to the present needs of the Air Force than an auditory system such as the radio telephone and radio telegraph transmission in current use. Possibilities for the technical development of visual systems appear not to be as limited as those of auditory systems. Since visual systems require a shorter time for message presentation than auditory systems, are less subject to the type of distortion commonly affecting spoken language, and afford lasting referability with relatively little difficulty, they seem to enjoy a natural advantage over auditory systems.

In line, then, with the proposed use of a visual system of message presentation, either alone or in conjunction with auxiliary auditory messages, psychological research has been initiated at the University of Virginia under an Air Force contract to determine the relative efficiency of auditory and visual message presentation.

### The Rationale of a Literature Survey

Certainly one of the most useful tools with which a research scientist can be equipped is a comprehensive bibliography of the previous work that has been done in his field of investigation. In the light of the findings of other investigators, the experimenter is better able to determine the most significant problems to be studied; he is informed of pertinent variables for control and manipulation and of possible techniques to use in experimental design. A great deal of research has been done on the rela-

tive efficiency of an auditory or visual presentation of verbal material; thus it is to be expected that a comprehensive literature survey would provide specific proposals of value to the organization of a related research program.

### Scope of This Survey

A great many psychological factors must be considered in a thorough investigation of the relative advantages of visual and auditory message presentation systems. The peculiar characteristics of the eye and ear as sense receptors, for example, undoubtedly play a part in determining the most effective system. However, in this survey not all of the psychological and physiological factors involved in message presentation will be considered. Such a survey of broader scope is in current preparation. The present survey is limited to a review of the previous experimental work that is concerned directly with a comparison of the relative efficiency of the comprehension of visually and aurally presented verbal material. Essentially only those experiments will be included in this survey in which a particular type of information is presented both visually and aurally to subjects who are then tested for their comprehension of the material. This basic experimental design has been investigated under a relatively large number of conditions. The specific questions in terms of which the present survey will be oriented are: (1) Is material more easily understood when presented visually or aurally? (2) Under what conditions and to what extent is each of the methods more efficient with respect to the comprehension of material? The results of previous experimental work will be regarded in terms of these questions, and the implications of these findings for future Air Force communication research will be considered.

## **THE LITERATURE SURVEY**

### Methodology of the Survey

In the experimental research associated with the relative ease with which visually and aurally presented material is learned or retained, a number of different variables has been investigated under a wide variety of experimental conditions. In general, the variables have been: (1) type of material presented (e.g., nonsense syllables, digits, discrete words, prose selections); (2) the characteristics of the subjects (intelligence, age, education, social position, reading skill); (3) the method of presentation of the material (exposure device, slide projection for visual

material; visible speaker, voice recording for auditory material); (4) the measure of comprehension of the material (learning or retention, immediate or delayed recall, essay test or multiple-choice questions); and (5) the characteristics of the material (easy or difficult, meaningful or meaningless, rate of presentation). For purposes of convenience only, the literature will be grouped in this survey according to the type of material presented and will be reported chronologically within each grouping.

## Review of the Literature

### 1. Nonsense syllables

Whitehead (31), in 1896, using nonsense syllables found learning to be superior with a visual presentation, when retention was measured, the auditory mode was superior.

Pohlmann (23), in 1906, with three recall intervals and six modes of presentation, concluded that for familiar meaningful material auditory presentation is slightly superior to visual, while for nonsense syllables visual presentation is more effective.

Von Sybel (30), in 1909, used nonsense syllables in six modes of presentation; he found a visual-auditory-motor combination superior to simple visual presentation for learning.

Henmon (12), in 1912, using nouns, numbers, and nonsense syllables (none of which contained c's, q's, or h's), found the auditory presentation definitely superior for all materials and for all six subjects. Visual-auditory-motor combinations were next best, and simple visual presentation was least effective.

O'Brien (22), in 1921, compared ten modes of combinations of visual, auditory, vocimotor (silent reading), and manumotor (writing), in addition to visual and auditory presentations alone. Using nonsense syllables and four-letter words he concluded that no one of the twelve modes of presentation was consistently superior.

Koch (14), in 1930, presented nonsense syllables aurally by spelling the syllables at a rate consuming the same length of time as that consumed in the visual presentation. Retention was best for the visual-auditory method, next best for the visual method, and worst for the auditory method.

Reed (25), in 1931, employed pairs of nonsense syllables and short meaningful words to study the effect of a change of experimental conditions from the original learning to the testing period. A change in the method of presenting the stimulus words at recall from the method

used at the original learning period was detrimental to the 119 subjects.

Krawiec (15), in 1946, determined the relative value of the two modes of presentation for the complete learning and retention of non-sense syllables and three-letter words, testing at intervals of one and two weeks. Using the method of anticipation for the measure of learning, he found the visual mode superior for the learning of both types of material. Neither mode was found to be consistently superior for retention. Although the auditory mode seemed to favor the retention of nonsense syllables at one week while the visual mode was very slightly superior for retention after two weeks, the differences were not significant.

## 2. Digits

Münsterberg and Bigham (21), in 1894, using colored squares and series of numbers either exposed for two seconds or named by the experimenter, tested their subjects for retention by the reconstruction method. They found a combination of visual and auditory presentation to be most effective, with visual presentation alone next best, and with auditory presentation least effective.

Smedley (28), in 1900, found a combination of visual and auditory presentation superior for the immediate memory of digits by school children. Below ten years of age the auditory method was superior to the visual, while after that age the visual method became superior.

Schuyten (27), in 1906, tested students with eight two-place numbers and found auditory presentation superior to a visual-auditory combination.

Conway (4), in 1909, tested the memory span for series of from three to nine digits and found the auditory method superior from the ages of six to nine, from these ages until fourteen, the visual method was superior.

Gates (9), in 1916, found visual presentation superior for tests of memory span.

## 3. Discrete words

Quantz (24), in 1897, tested memory for words presented visually and by a combined method. He found a combined visual-auditory presentation to be of insignificant advantage over either the visual or auditory mode separately.

Lay (18), in 1910, found that in the presentation of material for learning spelling, the visual method was superior to the auditory.

Kempsies (13), in 1900, presented German-Latin vocabularies to school children and found the visual method superior. He also used non-

sense syllables and found either single method usually to be superior to a combination of visual and auditory presentation.

Calkins (3), in 1898, and McDougall (20), in 1904, using meaningful words found visual presentation superior for immediate and delayed recall.

Pohlmann (23), in 1906, used three recall intervals and six modes of presentation and concluded that for familiar meaningful material, such as words, auditory presentation is slightly superior to visual. His subjects were nine to fourteen year-old school children; he found that the visual presentation increased in effectiveness with age until it finally surpassed the auditory mode.

Henmon (12), in 1912, found the auditory method superior for meaningful nouns.

Carver (2), in 1941, used words as well as other types of material. He found a visual presentation consistently superior when difficult words were employed. When lists of easy words were used, however, the auditory mode was more effective.

Krawiec (15), in 1946, using nouns as well as nonsense syllables, found the visual method superior for learning the material, but neither method superior for delayed recall.

#### **4. Meaningful prose**

Erickson and King (8), in 1917, presented school lessons visually and aurally to children in four grade groups from third through ninth grades. Auditory presentation was found to be superior for all four groups.

Lacy (16), in 1918, used tests of factual information, moral discriminations, and inferences; he found the auditory presentation to be superior for 315 boys in the seventh to the ninth grades.

Worcester (33), in 1925, presented meaningful, connected material to 13 subjects, measuring retention for immediate and delayed recall. He found that neither the visual nor the auditory mode proved to be superior for rate of learning. The auditory mode, however, was proved to be superior to the visual for retention.

Russell (26), in 1928, administered a one-thousand-word passage to 690 pupils to compare visual and auditory modes of presentation. He found the auditory mode superior for the fifth grade students, no difference in the seventh grade, and visual superiority for the ninth grade pupils.

Greene (11), in 1928, presented oral and printed lectures to college

students. Neither method was found to be superior in immediate test, but the auditory method was somewhat superior as measured by delayed recall. Students of higher ability tended to show greater retention after visual presentation; those of lower ability tended to retain better after auditory presentation.

Lumley (19), in 1933, presented factual lessons aurally and visually to children in the fifth through eighth grades. The visual method was found to be superior, and the seventh and eighth grades favored the visual method more than did the fifth and sixth grades.

Corey (5), in 1934, presented factual material to college students visually and aurally, and tested for retention by immediate and delayed recall. He found the visual method superior for immediate recall and slightly superior after two weeks. Superior students and better readers did relatively better for visual presentation than did poorer ones.

Wilke (32), in 1934, presented propaganda by the two methods and found that opinions were influenced most by spoken material, somewhat less by material presented over a loud speaker, and very little by printed material.

Young (34), in 1936, tested comprehension in hearing and reading for pupils in the fourth, fifth, and sixth grades; the auditory mode was found superior for all grades, but less so for the sixth grade.

Larsen and Feder (17), in 1940, presented meaningful factual material of three levels of difficulty to college students both aurally and visually. Neither method was superior for easy material, but visual presentation was slightly superior for material of moderate difficulty.

Goldstein (10), in 1940, using a number of different rates of presentation of meaningful materials of different difficulty, found that auditory presentation was superior to visual presentation; this superiority, diminishing with increasing rates of presentation, was greater for easy than for difficult material, greater for the less intelligent subjects, and greater for the slower than for the faster readers.

## **5. Advertising copy**

Burt and Dobell (1), in 1925, conducted an experiment upon the relative merits of early and late repetition for memory of fictitious trade names, and found very little difference as a result of the mode of presentation.

Stanton (29), in 1934, using fictitious advertising copy, measured immediate and delayed recall and found the auditory mode superior in all cases, although the difference was less significant after a lapse of twenty-one days.

DeWick (6), in 1935, measured immediate and delayed recall of advertising material presented visually and aurally and found no advantage for either method in immediate recall, but a superiority of the auditory method for delayed recall.

Elliott (7), in 1936, found an auditory presentation superior to a visual one. A combined visual-auditory stimulation ranked above the auditory alone.

## SUMMARY AND CONCLUSIONS

### Summary of the Survey

The results of the experimental research that has been reviewed above have now to be evaluated in terms of the two orienting questions which were stated in the Introduction to be the primary consideration of this literature survey. These questions are again: (1) Is material more easily understood when it is presented visually or aurally? and (2) Under what conditions and to what extent is each of these methods of presentation relatively more efficient with respect to the comprehension of material?

The implications of the experimental evidence for the first of these questions is quite clear. Approximately half of the research has favored a visual, and half, an auditory method of presentation. It must then be concluded that neither an auditory nor visual presentation of information is more suited per se to efficient comprehension. Strictly speaking, a comparison of the results of much of the research covered above can not be logically justified, since the experimental conditions upon which they are based vary widely from study to study. It is nevertheless apparent at once that any superiority of visual or auditory presentation depends upon the particular circumstances under which the comparison is made.

As a result, the proper consideration of the second orienting question becomes extremely important. The task is primarily to enumerate the special conditions under which either a visual or auditory presentation of information is consistently superior. Actually few if any, of the generalizations that can be made with respect to the relative superiority of one of the two methods are supported by all of the pertinent experimentation, and it must be remembered that the wide range of conditions under which the experimental work has been done make only a small number of the

studies strictly comparable. Nevertheless, eleven generalizations will be stated below which have been supported by the major part of the best relevant research. They indicate the circumstances which probably determine the superiority of a particular method of presentation.

In stating the references which provide the particular data from which these generalizations have been induced the following procedure will be followed. Reference to all data of possible relevance to the conclusion will be made. Listed first, however, will be references to the most pertinent experimentation and to research which directly or more indirectly substantiates the conclusion; references to evidence which fails to support the generalization will be stated.

1. A combined visual and auditory presentation of material leads to more efficient comprehension than the presentation of either auditory or visual material alone (7, 14, 21, 28, 30; 12, 13, 22, 24).

2. Meaningful, familiar material is more efficiently presented aurally, whereas meaningless and unfamiliar material is more efficiently presented visually (8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 23, 32, 33, 34; 3, 5, 9).

3. The greater the intelligence level of the receiver, the greater is the relative advantage of a visual presentation (5, 10, 11).

4. The greater the reading ability of the receiver, the relatively more effective is a visual presentation (5, 10).

5. The relative efficiency of a visual presentation increases with age from a definite inferiority at the age of six to a possible superiority at the age of sixteen (4, 8, 16, 19, 23, 26, 28; 13).

6. Unusually difficult material is more effectively received with a visual presentation, whereas particularly easy material is better understood with an auditory presentation. The relative effectiveness of the visual presentation increases with increasing difficulty of the material (2, 10, 17).

7. When comprehension is tested by an immediate recall of the material a visual presentation is favored; if the test of comprehension is made after a considerable interval of delay, an auditory presentation is favored (5, 6, 33; 3, 15, 20, 29).

8. The relative efficiency of a visual presentation diminishes as the interval of delayed recall increases (5, 6, 15, 29, 33).

9. One of the most significant advantages of a visual type presentation system is the relatively greater referability, or opportunity for reviewing the material, that it affords. It has been found that the less the referability afforded by a visual presentation system, the less is its advantage over an auditory presentation (10).

10. Such organized and related material as prose or factual information is better understood with an auditory presentation; material such as code that is comparatively discrete and unrelated is more effectively received with a visual presentation (3, 8, 10, 11, 13, 16, 18, 20, 23, 32, 34; 5, 12, 19).

11. The comprehension of material can be tested either by the ease with which the material is learned or by the amount which is retained after a period of time. As a rule, measures of learning tend to favor a visual presentation while measures of retention are higher after an auditory presentation (12, 31, 33; 14, 15, 21).

These eleven generalizations point out the specific conditions under which auditory and visual systems of presentation are respectively superior. The evaluation of particular presentation systems depends, then, upon their analysis in terms of the factors implied by these generalizations.

### Implications for Future Communications Research

In addition to the generalizations enumerated above, this survey has revealed that no experimentation dealing with the comprehension of actual messages similar to those employed in Air Force communication has been done as such. In order to assemble relevant literature at all, it has been necessary to regard as "messages" a wide variety of verbal material which finds perhaps better application in such other fields as grade school teaching or advertising. It is clear that the psychological research that would indicate solutions to more specific Air Force communication problems must yet be done. Indeed, as has been already indicated, it is the primary function of the present literature survey to provide a relatively more adequate familiarity with the design, techniques, and variables involved in such research, so that a comprehensive program of the most pertinent research projects can be wisely planned. It will be the attempt of the concluding section of this report to outline the broader problems that must be considered in a systematic investigation of the relative efficiency of visual and auditory systems for the intelligibility of Air Force messages.

Again the two orienting questions that were raised earlier will help to delineate the extent of this analysis. If one examines closely the form of the two questions, it becomes apparent that they are in effect mutually converse in structure. The results of this survey have indicated that no meaning can be given to the first question as it stands, whether or not a given presentation system is more efficient in an auditory or visual form depends upon the message, the system, and the receiver. Thus a more

useful statement of the first question takes the form: Under a given set of circumstances, which is more efficient for the comprehension of messages, an auditory or visual presentation? This is the structural converse of the second question: Under what particular circumstances is an auditory or visual presentation more efficient for the comprehension of messages? A different avenue of approach must be followed in planning research in connection with these two questions.

Research undertaken in line with the first of these questions takes the form of an actual comparison of existing communication systems. Accordingly, the results of such investigations would simply state that as far as intelligibility is concerned, one particular form of message presentation is more efficient than another. For example, the comprehension of messages that are presented by radio telephone can be compared with that when a facsimile type presentation system is used. The concrete data provided by this type of research are indeed useful and find ready application to many Air Force communication problems. It is clear, however, that such research demands as a prerequisite that the transmission systems be already devised; it is consequently only indirectly applicable to the new design of more efficient systems. Nevertheless, this general type of research can be profitably initiated to evaluate the relative efficiency of the communication systems in current use.

Data more directly relevant to the design of improved communication systems would be derived from a second broad type of research. This general type of research would attempt to establish relationships of relative efficiency between the visual or auditory presentation of messages on the one hand, and a series of variables which have been found to influence their comprehension on the other. The classification of variables that was made earlier in this report can now be conveniently employed to indicate the most relevant research of this general nature.

(1) Type of material. Research can be initiated in which the material presented consists of communication messages such as are in actual use by the Air Force today. Different types of messages, varying in both content and form, could be investigated for their relative intelligibility under visual and auditory presentation.

(2) Characteristics of the human receiver. The relative efficiency of visual and auditory presentation should be studied with Air Force personnel as subjects. The age, training, and general background of these men may conceivably have considerable influence upon the form in which messages are more reliably understood.

(3) Method of presentation of material. The influence of these factors that are inherent within particular visual and auditory presentation systems and determine the efficiency of comprehension should be investigated.

(4) Measure of intelligibility of material. In the broadest sense, research can be included in this category that is related to the effectiveness of communication with respect to the end purposes it is intended to serve. Here the emphasis of the investigation is placed upon the ultimate suitability of the communication system as reflected in the behavior of the receiving operator. In the last analysis, the proof of the adequacy of traffic control communication, for example, is simply whether or not the pilot has his aircraft at the directed altitude over the designated location at the proper time. If an airplane is not flying at its assigned position, it can be assumed that in some way the communication between pilot and tower has not been successful.

(5) Conditions of reception of the material. The particular conditions under which a message is received may have a differential influence upon the interpretation of messages when they are presented visually or aurally. Research in this area would include the relative influence of such factors as noise and interference effects upon visual and auditory presentation. The experimental investigation of the problem of divided attention is of particular significance here. The design of the aircraft in use today requires that the receiver of aviation communications also perform certain other tasks that are necessary for the efficient functioning of the airplane as a unit. It is quite possible that when message reception is investigated under conditions where the receiver is simultaneously occupied with other tasks, a significant advantage of either an auditory or visual message presentation system will appear.

The five general areas of experimentation that have been outlined above have been stated in necessarily broad terms for the sake of inclusiveness; they consequently do not recommend any specific project for immediate undertaking. The next step in a systematic approach to the comparison of visual and auditory message reception could be an extensive enumeration of the individual factors within each area that are relevant to communication needs. It is believed that an integrated approach of this nature would be more rewarding to the Air Force in the final analysis than the separate considerations of the perhaps more interesting, but nevertheless isolated problems that are more readily apparent.

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